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(56) Documents to be considered for evaluation of the patentability:

DE	198 20 570 A1
DE	198 16 549 A1
DE	44 33 056 A1
DE	698 06 100 T2
DE	696 12 165 T2
GB	21 11 171
US	62 79 702 B1
EP	12 73 820 A2
EP	12 19 858 A1
EP	05 81 476 A1
EP	04 01 009 A1
EP	03 82 171 A1

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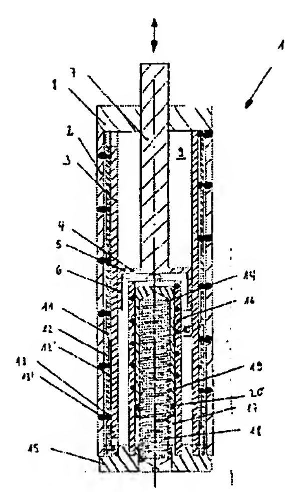
(54) Designation: Vibration damper based on electrorheological and/or magnetorheological fluids

(57) Abstract: A vibration damper based on electrorheological and/or magnetorheological fluids having a cylinder housing (2/3), an axially displaceable working piston (4) which divides the cylinder housing (2/3) in two pressure medium chambers (9, 10) and which is connected to a piston rod (7), wherein the pressure medium chambers (9, 10) are filled with an electrorheological and/or magnetorheological fluid and wherein at least one flow channel (12, 12') connecting the pressure medium chambers (9, 10) is disposed and wherein the at least one flow channel (12, 12') can be supplied via an electric and/or magnetic field, and wherein in one pressure medium chamber (10) a relieving piston (14) for compensating the piston rod volume is provided, shall be further designed such that it can be applied in a further technical field. This is achieved by assigned a valve means (19) which can be actuated for impacting on the compensating movement of the relieving piston (14) to the relieving piston (14).



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Description

The use of vibration dampers is known in a plurality of technological fields, e. g. in the field of machine and vehicle construction. In motor vehicles, for example shock absorbers are used for increasing the driving safety and the comfort.

The principal structure of shock absorbers based on electrorheological fluids is known among others from the document "Technischer Einsatz neuer Aktoren", Expert-Verlag, 1995, page 57 and 58. In these shock absorbers, two pressure medium chambers in a cylindrical housing are divided by a piston, wherein for example the piston possesses fluid passage openings through which flows the electrorheological fluid. The damping force of the vibration damper in pullout stroke and pressing stroke can be variably adjusted by altering the rheological properties of the fluid.

Electrorheological fluids are generally suspensions, i.e. solid particles which are suspended within a carrier medium which can be polarized via the electric or respectively magnetic field.

It is well known that the impact of an electric or respectively magnetic field is capable of adjusting the viscosity of electrorheological or respectively magnetorheological fluids in a to a large extent fast and reversible manner. In electrorheological fluids, an electric control voltage is applied to arrangements of electrodes for generating an electric field. The interaction between the arrangement of electrodes and the electrorheological fluid can be distinguished according to three principal modes dependently on the type of fluid deformation, the Shear-Mode (electrodes are being displaced relatively to each other in parallel planes), the Flow-Mode (electrodes are disposed fixed, the fluid flows through between the electrodes) and the Squeeze-Mode (electrodes have an altering distance to each other). These modes can also be present in combinations. Further information can be found in the book "Technischer Einsatz neuer Aktoren", Expert-Verlag 1995, chapter 2.3.1 and picture 3.1.

In dampers according to the Flow-Mode principle, the electrorheological liquids flows, due to a piston movement, through a separate flow channel (EP-0581476) which interconnects the pressure medium chambers and which

possesses an electrode arrangement. In another embodiment, the piston itself consists of an arrangement of concentric electrodes which are alternately polarized. In both cases, it is possible to control the flow resistance of the electrorheological fluid and thus, the damper behaviour by an electrical field.

From the DE 4433056, a vibration damper is known which works with a magnetorheological fluid. In this damper, a piston moves within the cylinder which divides the cylinder in two pressure medium chambers, wherein the pressure medium chambers can be connected via a flow channel which is formed between the piston peripheral area and the inner wall of the cylinder. In the area of the flow channels, a magnetic field is generated which acts upon the magnetorheological liquid in order to alter the damping proprieties of the damper (Shear-Mode).

From the EP 0401009 A1, a vibration damper is known which works with an electrorheological fluid. Therein, the flow channels which interconnect the pressure medium chambers are formed by fluid passage openings disposed in the piston (Flow-Mode) or by an annular gap situated between cylinder housing and peripheral area of piston (Shear-Mode). In the area of the flow channels, an electrical field which can be controlled is subsequently generated.

Objective of the present invention is to further develop a vibration damper based on electrorheological and/or magnetorheological fluids such that the shock absorber can be employed in a large technical application filed.

This objective is resolved according to the characterizing part of the patent claim 1 by the fact that a valve which can be actuated is assigned to the relieving piston for impacting the compensating movement of the relieve piston. By additionally actuating the relieve valve, the damper force is altered, wherein the upper characteristic line of the base resistance remains the same.

The objective is furthermore resolved by the features indicated in the claim 4. By disposing a further flow channel which interconnects the pressure medium chambers in the area of the working piston, wherein valve means are assigned to the flow channel, which have an impact on the flow channel, i.e. result in an altered cross-section of the flow channel when being actuated, the hydraulic basic resistance of the shock

absorber can be varied. At the same time, the damper characteristic map can be constructed above the base characteristic line by actuating the electrically drivable flow channels. In a preferred embodiment, the impact which is exerted upon the flow cross-section in the area of the working piston is achieved by actuating a piezo-actuator.

A further example of embodiment provides an impact on the flow cross-section dependently on the stroke via a mechanical system.

The invention will be further described on the basis of multiple examples of embodiment which are represented in the figures.

The shock absorber 1 which is represented in the fig. 1 in a longitudinal section is designed as two-tube shock absorber and has a cylindrical outer and a cylindrical inner sleeve 2,3 which is disposed coaxially thereto. A working piston 4 is supported axially displaceable in the inner sleeve 4. The axial displacement of the working piston 4 is represented by the arrows which indicate the pullout and pressing stroke. The working piston 4 is designed as a cup-shaped piston, i.e. it possesses a disc-shaped portion 5 and a hollow cylindrical portion 6 which is attached thereto. On the side which is opposite to the hollow cylindrical portion 6 of the disc-shaped portion 5, the working piston 4 is connected to a piston rod 7 which is lead out of a covering part 8 in a sealed manner and which closes the inner and outer sleeve 2, 3.

The working piston 4 divides the inner sleeve 3 in two pressure medium chambers 9, 10 which in this example of embodiment are filled with electrorheological fluid. The pressure medium chambers 9, 10 are connected via the annular gap formed between outer and inner sleeve. The annular gap which is formed between outer and inner sleeve 2, 3 is divided by means of a further cylindrical sleeve 11 in two concentric annular gaps 12, 12' in the represented embodiment. Both annular gaps 12, 12' are respectively designed as flow channels which can be helically actuated. Therefor, a helically groove which is axially extending is inserted respectively into the inner envelope surface of the outer sleeve 2 as well as the outer surface of the inner sleeve 3, in which a helix 13, 13' consisting of an insulating material is inserted. The helix 13, 13' respectively is positioned in a sealing manner between outer sleeve 2 and further cylindrical sleeve 11 or

respectively further cylindrical sleeve 11 and inner sleeve 3. The envelope surfaces which border the flow channels 12, 12' are respectively designed as electrode surfaces. The outer sleeve 2 as well as the inner sleeve 3 is grounded, the further sleeve 11 is connected to a non-represented voltage line.

Due to the described structure, the first pressure medium chamber 9 is connected to the lower pressure medium chamber 10 via the flow channels which can be electrically driven. The viscosity of the electrorheological fluid can be controlled in the flow channels 12, 12' via an electric voltage signal. Hereby, the pressure difference between both pressure medium chambers 9, 10 and thus, the damping characteristic of the shock absorber 1 can be variably adjusted via the intensity of the electrical field.

In the lower pressure medium chamber 10, a relieving piston 14 is provided which is supported in an axially movable manner on a support sleeve 16 which is attached to the lower covering part 15 and extending into the pressure medium chamber 10. The relieving piston 14 is designed cylindrical and has a blind hole bore 17 in which a compression spring 18 is disposed which causes a respective return movement of the relieving piston 14. The compression spring 18 is fixed in the covering part 15 on its end side. Between the envelope surface of the support sleeve 16 and the outer envelope surface of the relieving piston 14, a further electrically drivable helical flow channel 19 is formed. In the flow channel 19 there is as well electrorheological fluid, wherein the flow channel 19 is sealed in direction lower covering part 15 via a seal 20 and is connected to the pressure medium chamber 10 in its upper end area. The electrically drivable electrode arrangements are therein formed by the outer envelope surface of the relieving piston 14 as well as the inner envelope surface of the support sleeve 16. The electrorheological fluid which is in this flow channel 19 can as well be altered concerning its viscosity by altering the electric field generated between the electrode arrangements.

When the flow channel 19 between relieving piston 14 and supporting piston 16 is not supplied by means of an electric field, a compensating movement in axial direction of the relieving piston 14 within the support sleeve 16 occurs at the moment of an axial movement of the working piston 4 of the shock

absorber 1. By means of this relieving piston 14, a volume compensation of the piston rod volume occurs.

By actuating the flow channel 19 between relieving piston 14 and support sleeve 16, it is now possible to restrain directly the desired compensating movement in axial direction of the relieving piston 14, i.e. the damping force can be altered in doing so. Since the relieving piston surface is smaller than the active piston surface of the working piston 4, only a blocking force which is reduced accordingly to the ratios of the respective areas is required for the complete blocking of the working piston. The small valve surfaces formed by the flow channel 19 on the perimeter of the relieving piston 14 result in the fact that the working piston 4 can be blocked with considerably lower energy consumption. By actuating the relieving piston 14, it is possible to additionally influence the damper characteristic line of the shock absorber 1.

In fig. 21, a further example of embodiment of a shock absorber 21 according to the invention is shown in a longitudinal section. Identical pieces which have already been described in reference to fig. 1 will have identical reference numbers.

The shock absorber 21 as well is designed as a two-pipe shock absorber and has a flow channel 12, 12' which is electrically drivable between outer and inner sleeve 2, 3. The pressure medium chambers 9, 10 are interconnected via the flow channel 12, 12'. A working piston 22 is supported axially displaceable in the inner sleeve 3, wherein the working piston 22 is designed multipart and consists of a cylindrical element 23 and a cup-shaped element 24.

On the side which is opposite the cup-shaped element 24 of the cylindrical element 23, a piston rod 25 which protrudes upwards is disposed which is designed hollow cylindrical. In the blind hole bore of the piston rod 25, a piezo-actuator 26 is present which is designed electrically drivable. The direction of the executable stroke of the piezo-actuator 26 is represented by the arrow 27. The piezo-actuator 26 is in active connection with a way transmission means 28, wherein the way transmission means 28 is a silicone mass which is contained in the cylindrical element and transmits a stroke caused by electric actuation of the piezo-actuator 26 in axial direction to approximately the tenfold stroke. Due to the axial movement of the piezo-actuator

26 and the respective way transmission by means of silicon mass, the cup-shaped element 24 can be pushed away from the cylindrical element in axial direction so that a gap S can be opened between cylindrical element 23 and cup-shaped element 24 of the working piston 22. As it is represented schematically in the fig. 2, the cylindrical element 23 as well as the cup-shaped element 24 are coupled to each other via guide bolts 29 and spring elements 30 so that a mutual locking against torsion is achieved and a return movement of the cup-shaped element 24 to the cylindrical front face which is faced to the cup-shaped element 24 when the actuation of the piezo-actuator 26 is reset.

In the initial state, the cup-shaped element 24 abuts against the cylindrical element 23 so that between upper and lower pressure medium chamber 9, 10, no flow connection is provided via the working piston 22.

In dependence of the actuation of the piezo-actuator 26, a gap between cylindrical element 23 and cup-shaped element 24 of the working piston 22 is opened as described above and the electrorheological fluid can flow into the lower pressure medium chamber 10 via flow bores which are inserted into the cylindrical element 23 as well as via the gap S.

In fig. 3, a further example of embodiment of a shock absorber 31 according to the invention is shown. Identical parts which have already been described in reference to fig. 1 will have identical reference numbers.

The shock absorber 31 as well is designed as two-pipe shock absorber and has a flow channel 12 which is electrically drivable between outer and inner sleeve 2, 3. The pressure medium chambers 9. 10 are interconnected via the flow channel 12. A working piston 32 is mounted axially displaceable in the inner sleeve 3 wherein the working piston 32 is designed multipart and consists of a disc-shaped element 33 provided with flow channels and a cup-shaped element 34 in which flow channels are inserted as well.

On the side which is opposite to the cup-shaped element 34 of the disc-shaped element 33, a piston rod 35 which protrudes upwards is disposed. On the lower covering part 36 of the shock absorber 31, a bolt 37 is disposed torque proof, wherein the bolt 37 protrudes into the blind hole bore of the cup-shaped element 34 of the working

piston 32 which is divided in two. On the envelope surfaces which are faces to each other, axial, helical guiding grooves are inserted which respectively lead into the cup-shaped element 34 as well as the bolt 37, which serve for receiving balls 38. The cup-shaped element 34 is axially displaceable and disposed pivotable relative to the disc-shaped element 33 of the working piston 32.

When the piston 32 which is divided in two is axially displaced in the inner sleeve 3, a torsion which is dependent on way of the cup-shaped element 34 relative to the disc-shaped element 33occurs due to the arrangement described above, whereby an opening or respectively alteration of the flow channels which are disposed in the piston and which interconnect the pressure medium chambers 9, 10 is achieved.

As a matter of course, it is also possible to use magnetorheological fluids instead of electrorheological fluids. When magnetorheological fluids are used, coil arrangements have to be provided for generating a magnetic field instead of electrode arrangements.

Claims

1. Vibration damper based on electrorheological and/or magnetorheological fluids having a cylinder housing (2/3), an axially displaceable working piston (4) which divides the cylinder housing (2/3) in two pressure medium chambers (9, 10) and which is connected to a piston rod (7), wherein the pressure medium chambers (9, 10) are filled with an electrorheological and/or magnetorheological fluid and wherein at least one flow channel (12, 12') connecting the pressure medium chambers (9, 10) is disposed and wherein the at least one flow channel (12, 12') can be supplied via an electric and/or magnetic field, and wherein in one pressure medium chamber (10) a relieving piston (14) for compensating the piston rod volume is provided, characterized in that a valve means (19) which can be actuated for impacting on the compensating movement of the relieving piston (14) is assigned to the relieving piston (14).

2. Vibration damper based on electrorheological and/or magnetorheological fluids according to claim 1, wherein the valve means (19) is designed as a valve based on electrorheological and/or magnetorheological fluids.

3. Vibration damper based on electrorheological and/or magnetorheological fluids according to claim 2, wherein the relieving piston (14) is mounted axially movable in a support sleeve (16) which extends into the pressure medium chamber (10) and the valve is formed based on electrorheological and/or magnetorheological fluids by an electrically drivable flow channel (19) between the inner surface of the envelope of the support sleeve (16) and the outer surface of the envelope of the relieving piston (14).

4. Vibration damper based on electrorheological and/or magnetorheological fluids having a cylinder housing, an axially displaceable piston which separates the cylinder housing into two pressure medium chambers which is connected to a piston rod, wherein the pressure medium chambers are filled with an electrorheological and/or magnetorheological fluid and wherein at least one fluid passage channel which connects the pressure medium chambers is disposed and wherein the at least one fluid passage channel can

be supplied via an electrical and/or magnetic field, characterized in that in the area of the working piston a further flow channel which connects the pressure medium chambers is provided wherein valve means for extending the characteristic map which impact on the further flow channel when being actuated, are assigned to the further flow channel.

5. Vibration damper based on electrorheological and/or magnetorheological fluids, wherein the actuation is dependent on way or dependent on pressure, electric, electromagnetic or piezo-electric.

6. Vibration damper based on electrorheological and/or magnetorheological fluids, wherein the valve means comprise a piezo-actuator as well as a means for the linear transmission and the flow cross-section can be impacted by actuating the piezo-actuator of the further flow channel.

3 sheets with drawings can be found in the following

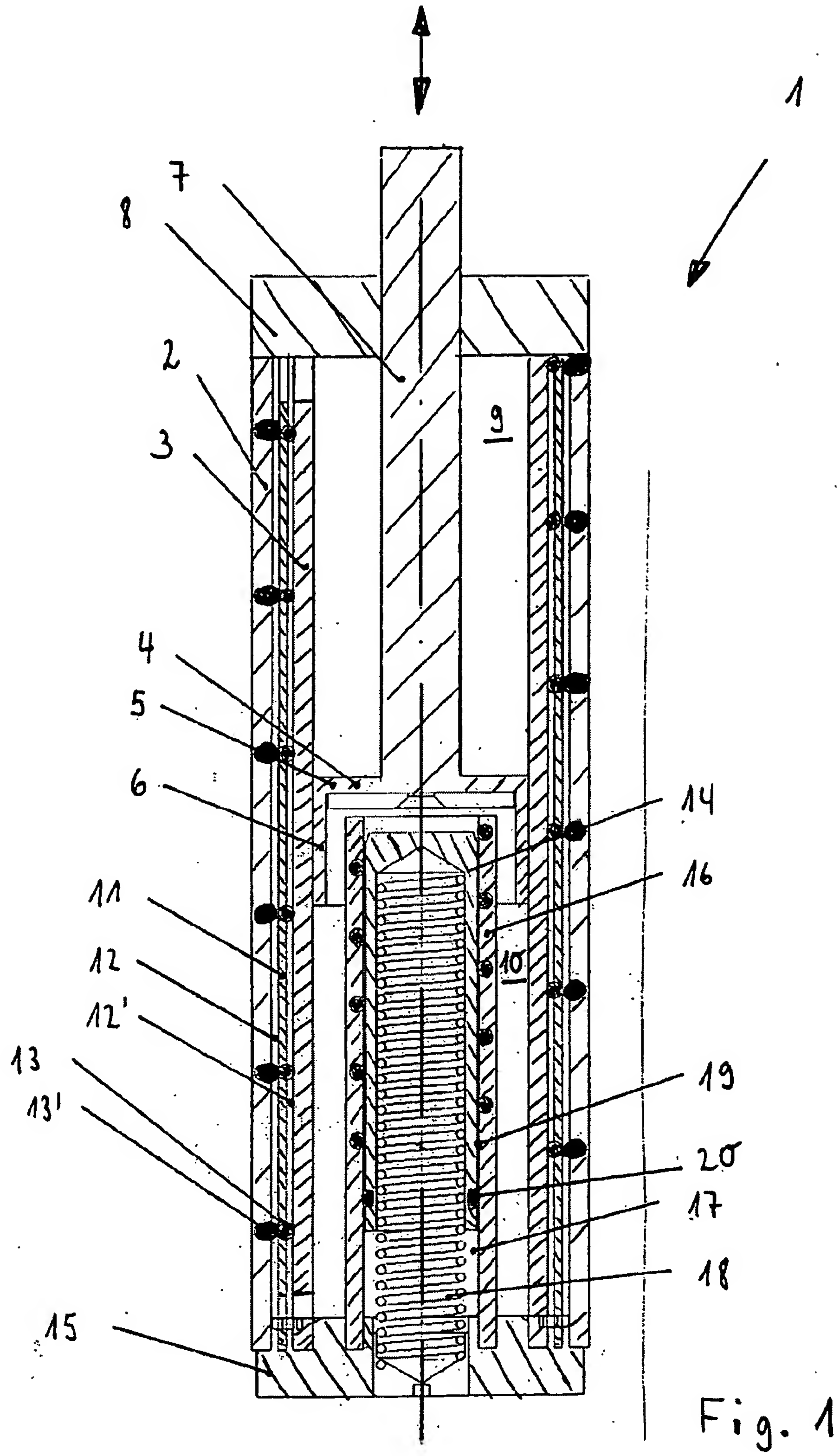

Fig. 1

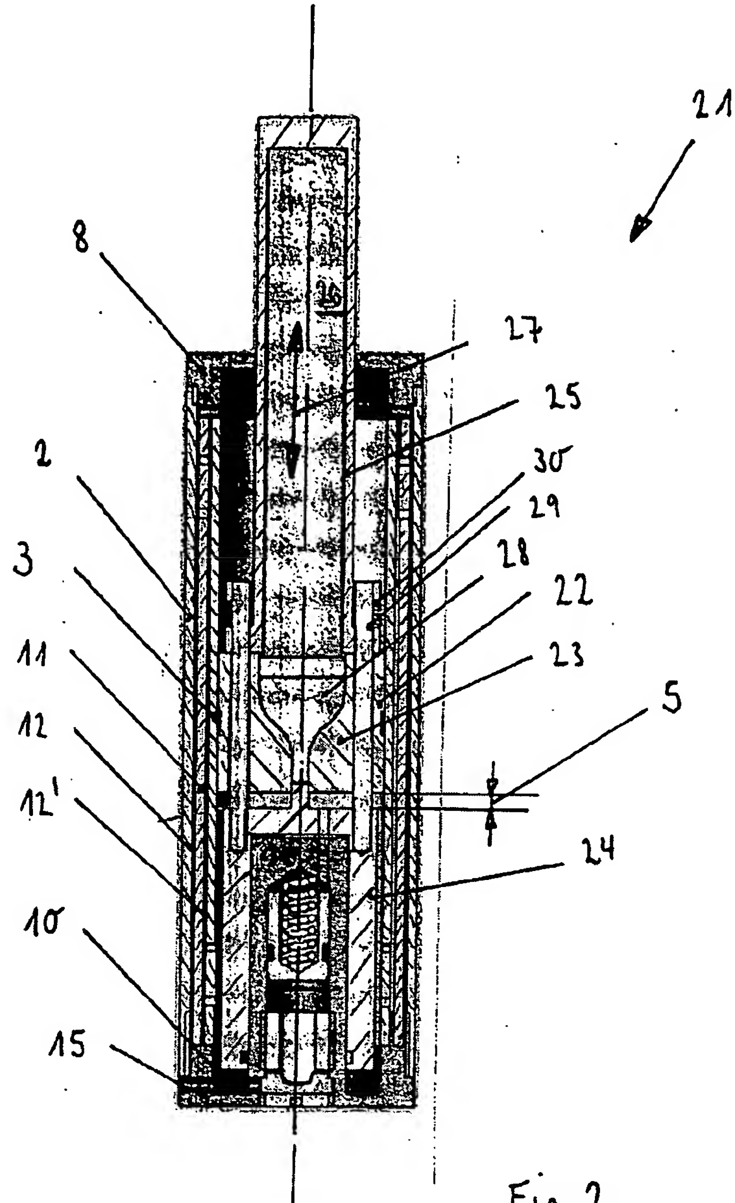

Fig. 2

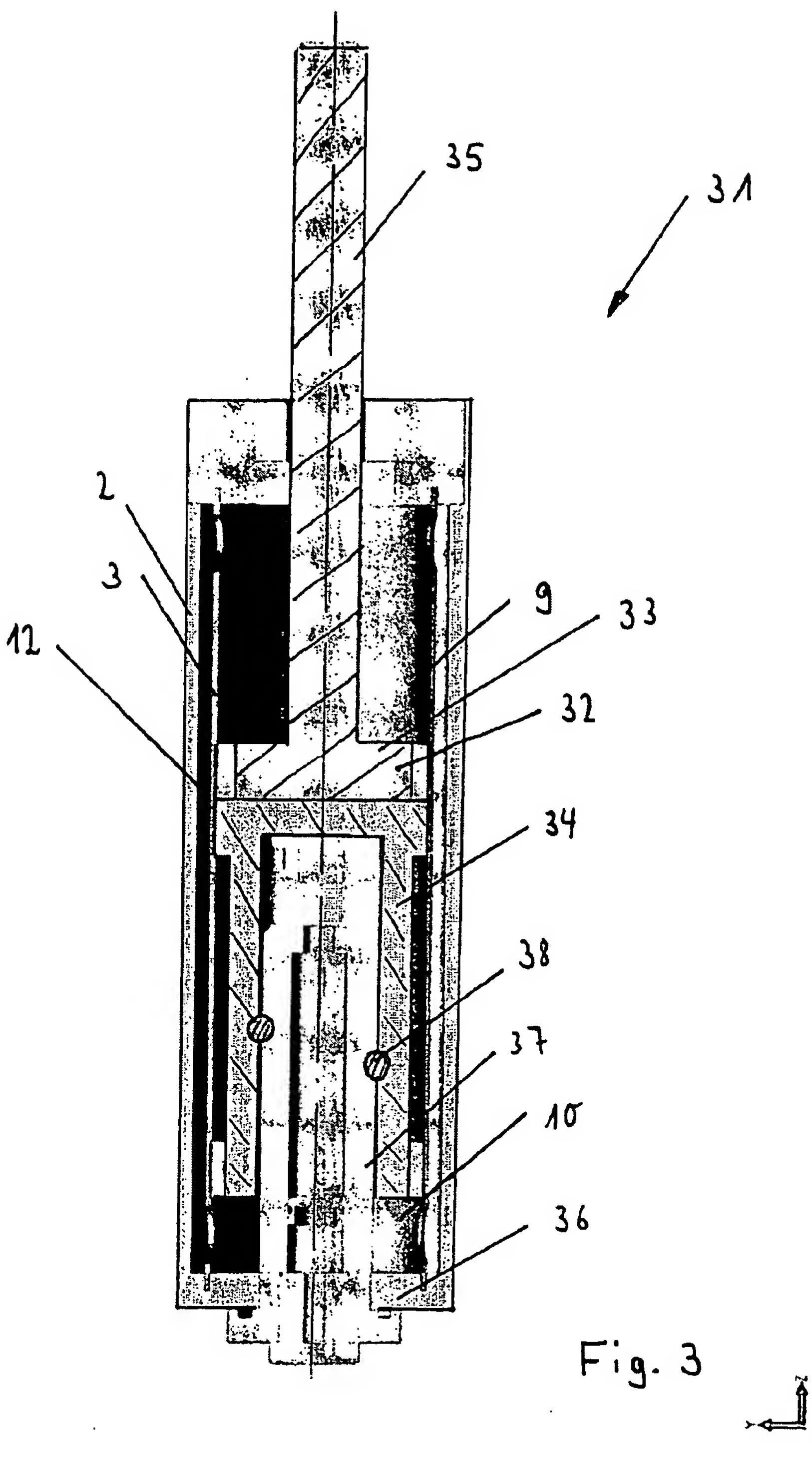

Fig. 3